EOS Microwave Limb Sounder

Nathaniel J. Livesey, Joe W. Waters, Lucien Froidevaux,
William G. Read, Michelle L. Santee, Dong L. Wu,
Jonathan H. Jiang, Gloria L. Manney, Hui Su,
Alyn Lambert, Michael J. Schwartz, Laurie J. Kovalenko,
Yibo B. Jiang, Robert F. Jarnot, Richard E. Cofield,
Paul C. Stek

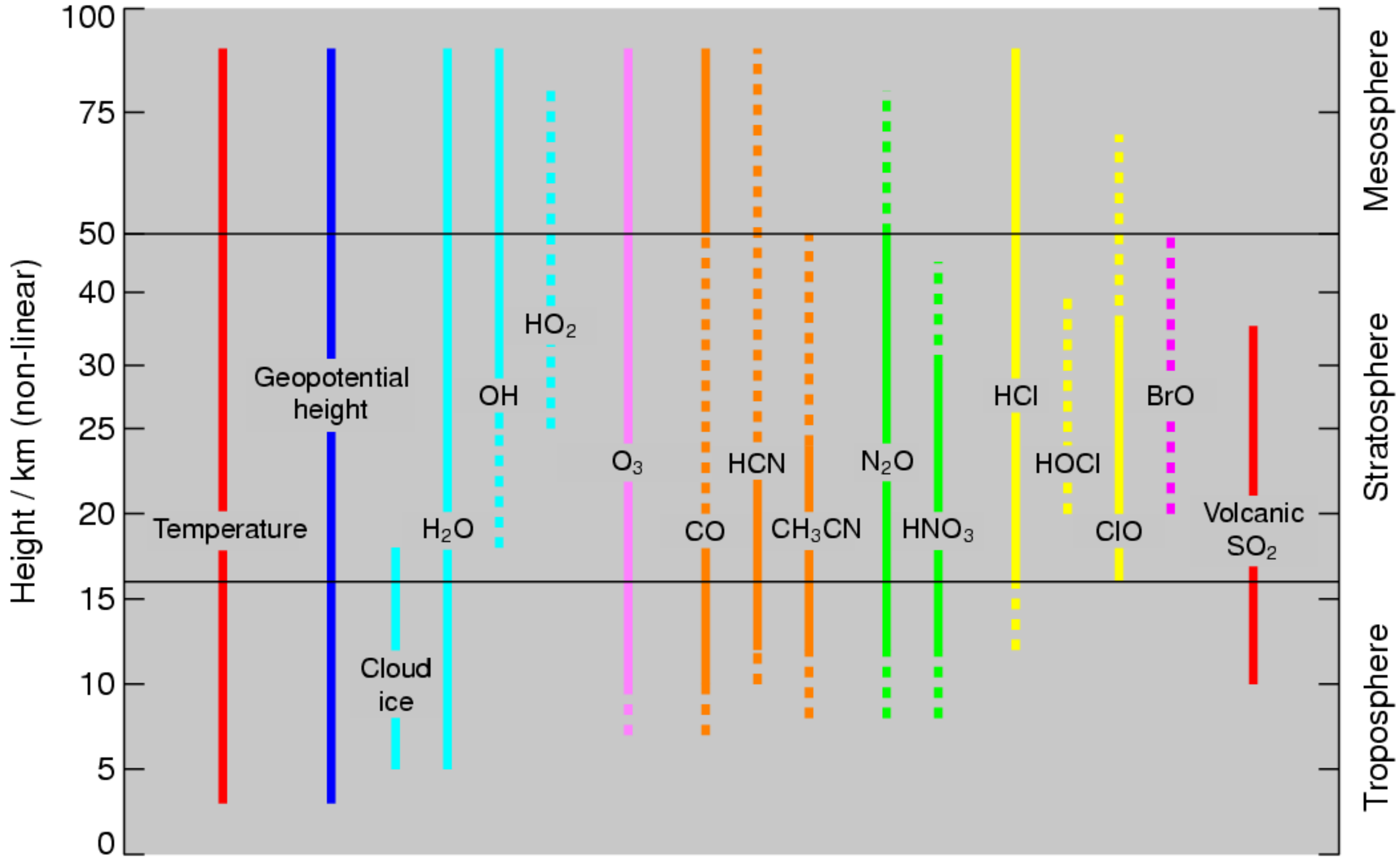
**Jet Propulsion Laboratory,
California Institute of Technology**

Hugh C. Pumphrey, Robert S. Harwood

University of Edinburgh

MLS Science and measurement goals

- Track the recovery of the ozone layer
- Understand aspects of how atmospheric composition affects climate
- Quantify aspects of pollution in the *upper* troposphere



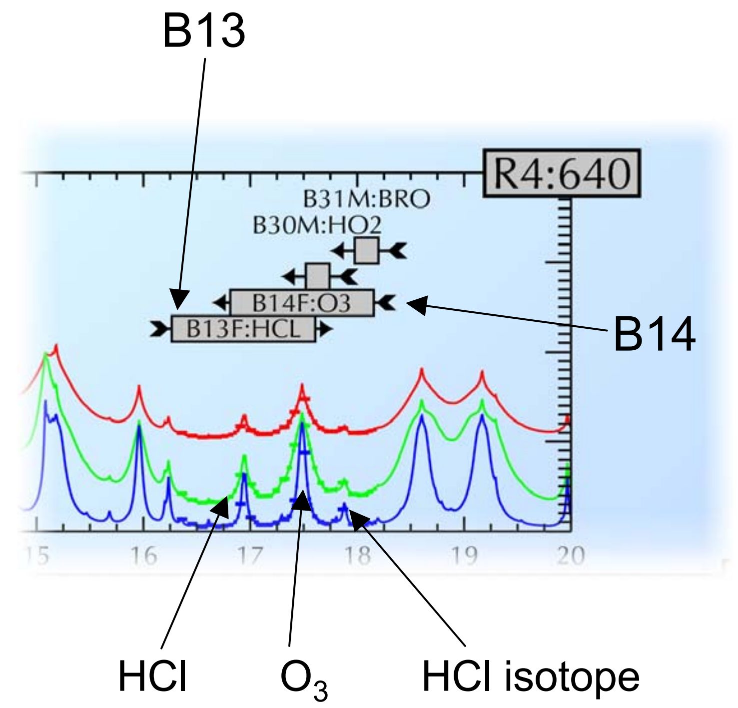
Significant MLS events

15 July 2004	Aura launch
24 July 2004	MLS ‘first light’
13 August 2004	Start routine MLS operations (L2 data produced 95% of the time since)
15 February 2005	First public release of v1.5 data
15 February 2006	Start duty cycling of HCl band 13 to conserve lifetime (HCl measurements now taken from band 14)
June/July 2006	End of funding for Mark Filipiak and Carlos Jimenez at University of Edinburgh, their responsibilities transferred to JPL team
22 August 2006	Start generating v2.1 data for selected days
11 September 2006	Joe Waters steps down as Principal Investigator. Nathaniel Livesey is new MLS P.I.
November 2006	Version 2.2 starts production
1 March 2007	MLS validation papers submitted to Aura special issue

- More details on instrument issues and changes in product responsibilities given in later slides

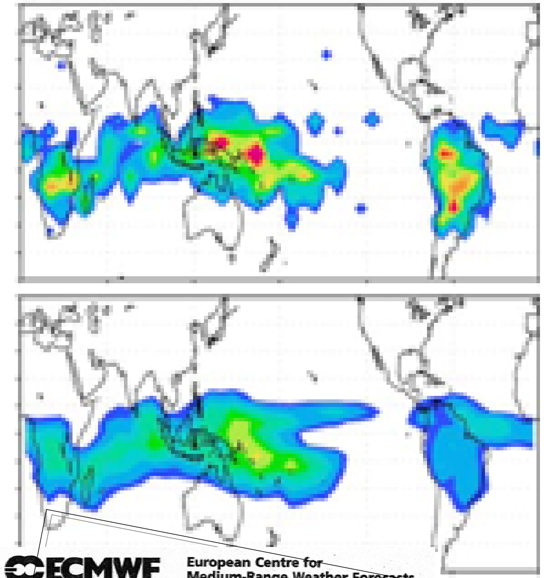
MLS HCl and ClO band lifetime issues

- Starting in February 2006, signs of aging seen in primary 640 GHz HCl band (B13)
  - Thought due to radiation hardness issues identified in a particular batch of transistors shortly before launch
- HCl data now taken from from adjacent band (B14)
  - B14 covers most of HCl line and also an isotopic HCl line
- B13 to be operated on occasional days to ensure consistency



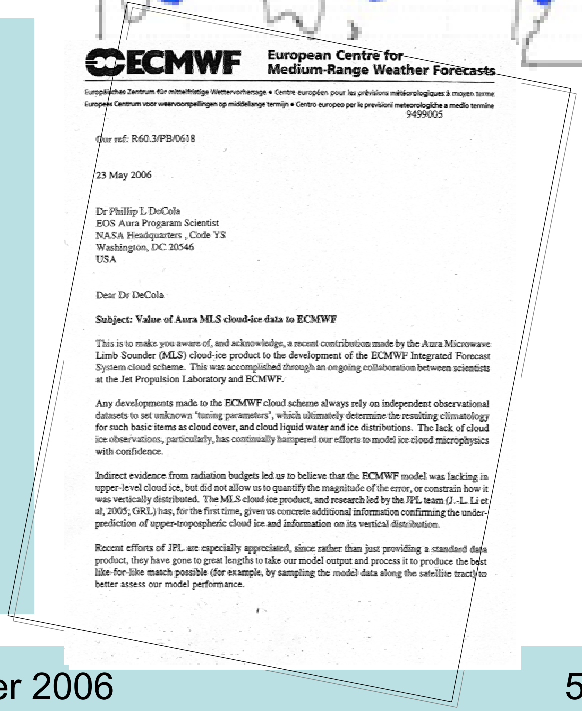
- Occasional small decreases in signal level seen in 640 GHz ClO band
  - At the current rate of decay, it will last nominal mission lifetime
  - ClO also measured at 190 GHz

MLS cloud ice data and model studies



- ➢ MLS provides new global maps of cloud ice water
- ➢ Initial comparisons with the ECMWF model (right) showed disagreements
- ➢ ECMWF is using MLS data to justify new cloud microphysics parameterizations
- ➢ This is leading to significant model improvements, particularly for tropical deep convection

> "…The MLS cloud ice product, and research led by the JPL team (J.-L. Li et al. 2005; GRL) has, for the first time, given us concrete additional information confirming the under-prediction of upper-tropospheric cloud ice and information on its vertical distribution…"
>
> Philippe Bougeault
> Head of ECMWF research department
> (unsolicited letter to Phil DeCola)



ECMWF European Centre for Medium-Range Weather Forecasts

Europäisches Zentrum für mittelfristige Wettervorhersage • Centre européen pour les prévisions météorologiques à moyen terme
Europees Centrum voor weervoorspellingen op middellange termijn • Centro europeo per le previsioni meteorologiche a medio termine

9499005

Our ref: R60.3/PB/0618

23 May 2006

Dr Phillip L DeCola
EOS Aura Progaram Scientist
NASA Headquarters , Code YS
Washington, DC 20546
USA

Dear Dr DeCola

Subject: Value of Aura MLS cloud-ice data to ECMWF

This is to make you aware of, and acknowledge, a recent contribution made by the Aura Microwave Limb Sounder (MLS) cloud-ice product to the development of the ECMWF Integrated Forecast System cloud scheme. This was accomplished through an ongoing collaboration between scientists at the Jet Propulsion Laboratory and ECMWF.

Any developments made to the ECMWF cloud scheme always rely on independent observational datasets to set unknown 'tuning parameters', which ultimately determine the resulting climatology for such basic items as cloud cover, and cloud liquid water and ice distributions. The lack of cloud ice observations, particularly, has continually hampered our efforts to model ice cloud microphysics with confidence.

Indirect evidence from radiation budgets led us to believe that the ECMWF model was lacking in upper-level cloud ice, but did not allow us to quantify the magnitude of the error, or constrain how it was vertically distributed. The MLS cloud ice product, and research led by the JPL team (J.-L. Li et al, 2005; GRL) has, for the first time, given us concrete additional information confirming the under-prediction of upper-tropospheric cloud ice and information on its vertical distribution.

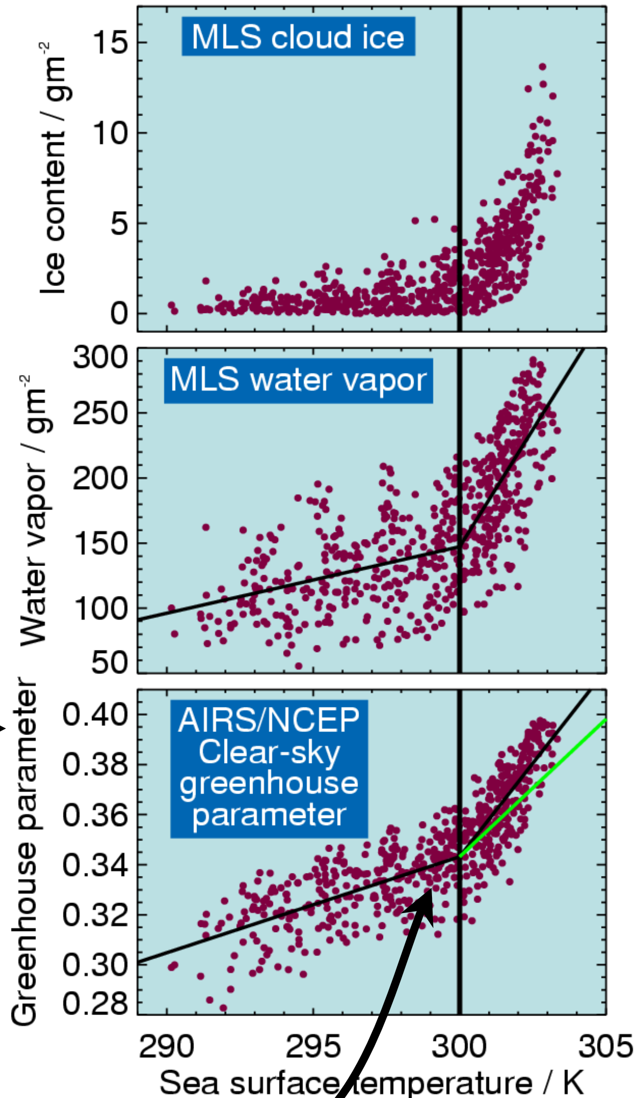
Recent efforts of JPL are especially appreciated, since rather than just providing a standard data product, they have gone to great lengths to take our model output and process it to produce the best like-for-like match possible (for example, by sampling the model data along the satellite tract) to better assess our model performance.

MLS studies 'super greenhouse effect'

- New MLS observations quantify the sharp increase in upper tropospheric cloud ice and water vapor with increasing sea surface temperature (SST) greater than 300K
- This implies that "convective water vapor feedback" is responsible for ~65% of the previously-known tropical "super greenhouse effect"

Greenhouse parameter (*g*) is fraction of radiation emitted by Earth's surface that is *not* radiated to space

"Super greenhouse effect" is change in gradient of *g* for SST > 300K (green line is MLS estimated convective contribution)



Su et al., GRL 2006 (see also talk 10:30am Friday)

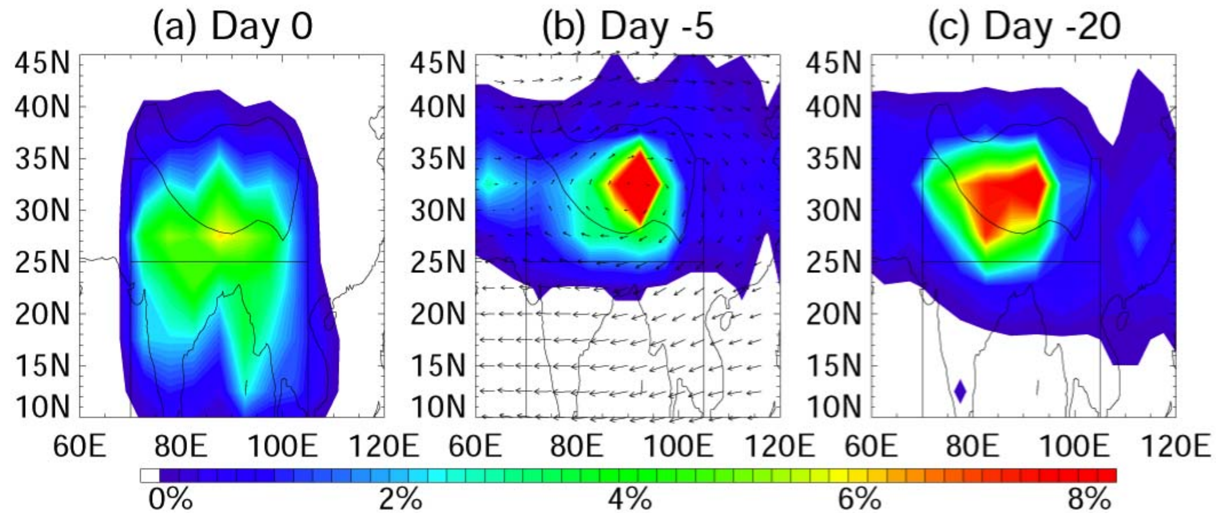
Shortcut to stratosphere over Tibetan Plateau

- MLS shows a large area of enhanced CO and water vapor at 100 hPa in the south Asia region during August
- Back trajectory studies indicate that the Tibetan Plateau is the preferred route for this air to enter the stratosphere
- While there is more convection (and pollution) over the Indian subcontinent, the convection over the Tibetan Plateau is stronger and can reach higher (partly due to the warmer tropopause)

Fu et al., PNAS 2006 (see also talk 9:30am Thursday)

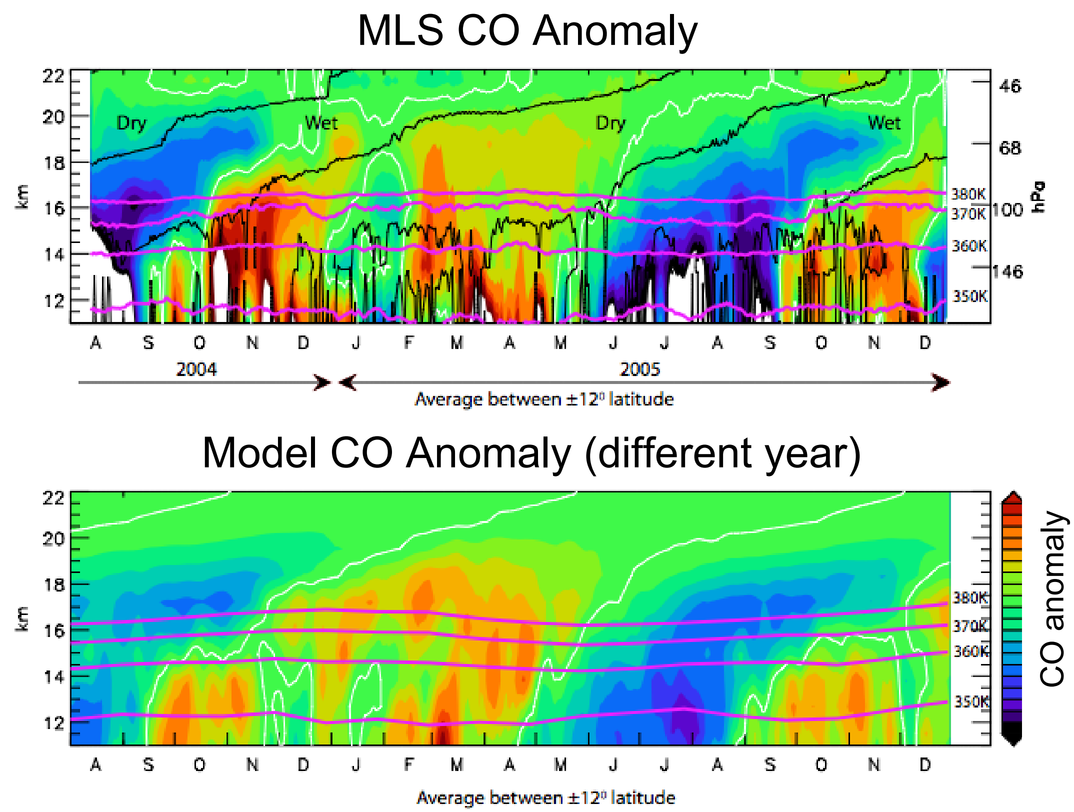
(a) Concentration of high (>80 ppbv) 100 hPa CO samples from MLS

(b,c) Distribution of same air 5, 20 days earlier (from back trajectory calculations)



MLS sees new 'tape recorder' signals

- The water vapor 'tape recorder' signal is well established
  - Imprint of the seasonal tropopause temperature cycle is carried upwards in the humidity of slowly ascending stratospheric air
- MLS has also seen 'tape recorder' like signals in CO, HCN and O_3
- Reflecting cycles in tropospheric pollution
- CO tape recorder described in *Schoeberl et al., [GRL 2006]*
- More details in posters by Mark Schoeberl and Hugh Pumphrey at this meeting



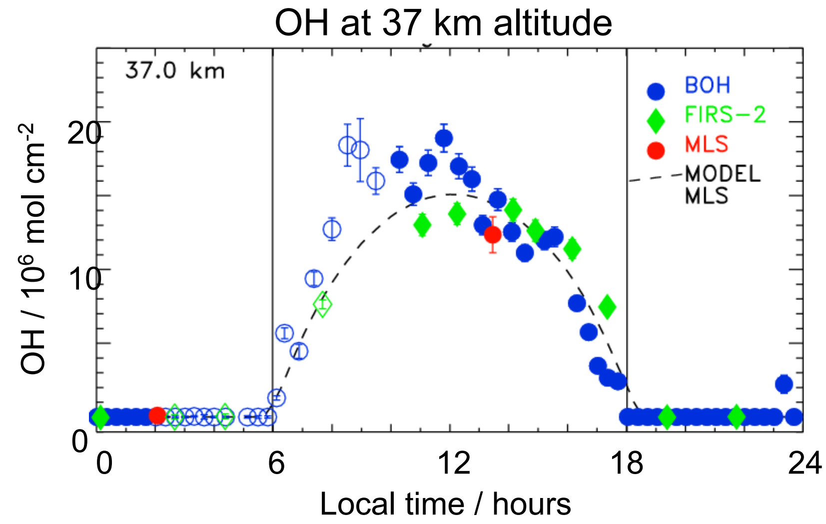
MLS studies the 'HO$_x$ dilemma'

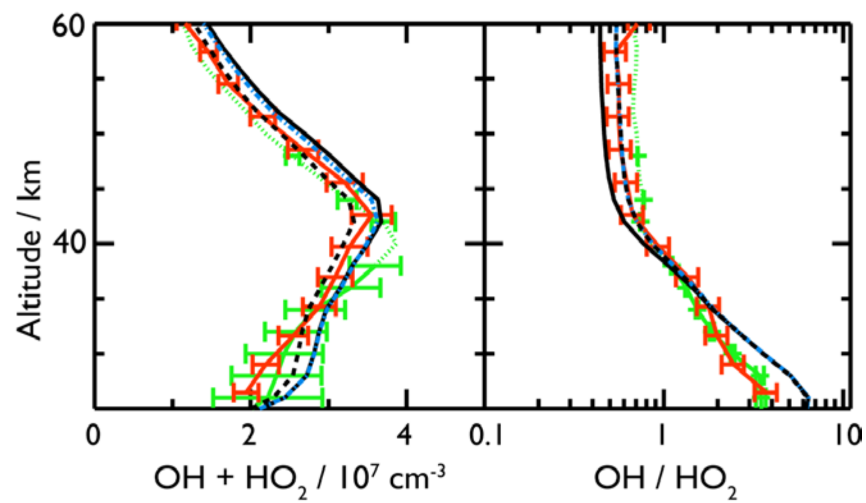
- MLS (red) is in good agreement with balloon (green, blue) HO$_x$ observations
- MLS data also show excellent agreement with models

  [Pickett et al., GRL 2006]

  [Canty et al., GRL 2006]

- See also Tim Canty's poster (Wed/Thu) and Herb Pickett's talk in the radicals session (Tuesday pm)

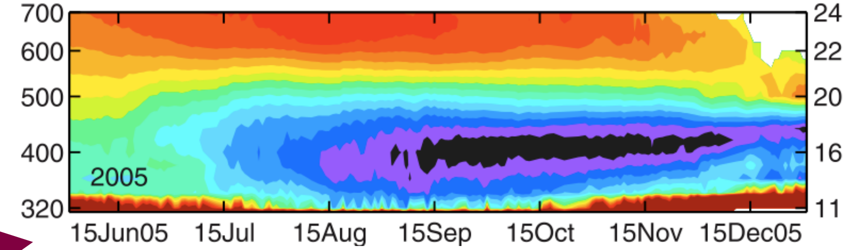


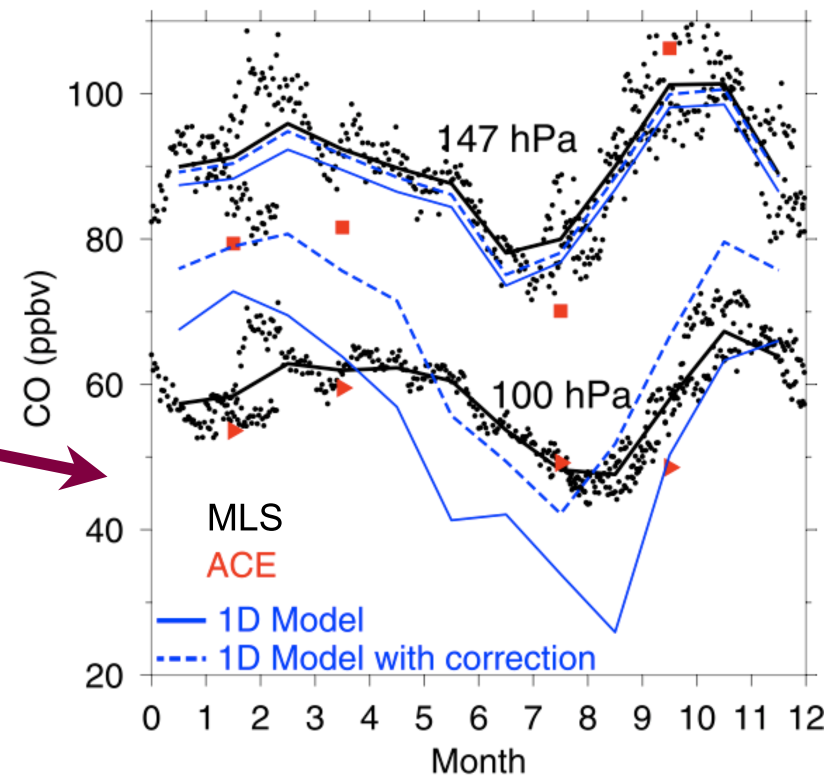


MLS observations do not indicate a 'HO$_x$ dilemma'

Some other recent MLS publications

- Quantification of 2004/2005 Arctic Ozone loss
  [Manney et al., GRL 2006]
- Studies of polar vortex dehydration
  [Jimenez et al., GRL 2006]
- Simultaneous observations of a polar vortex filament by MLS and Mauna Loa Lidar
  [Leblanc et al., GRL 2006]
- Seasonal cycles in CO and O_3 in the tropical tropopause region
  [Folkins et al., GRL 2006]
- MLS upper stratospheric BrO observations used to estimate 18.6±5.5pptv of Br_y
  [Livesey et al., GRL 2006]





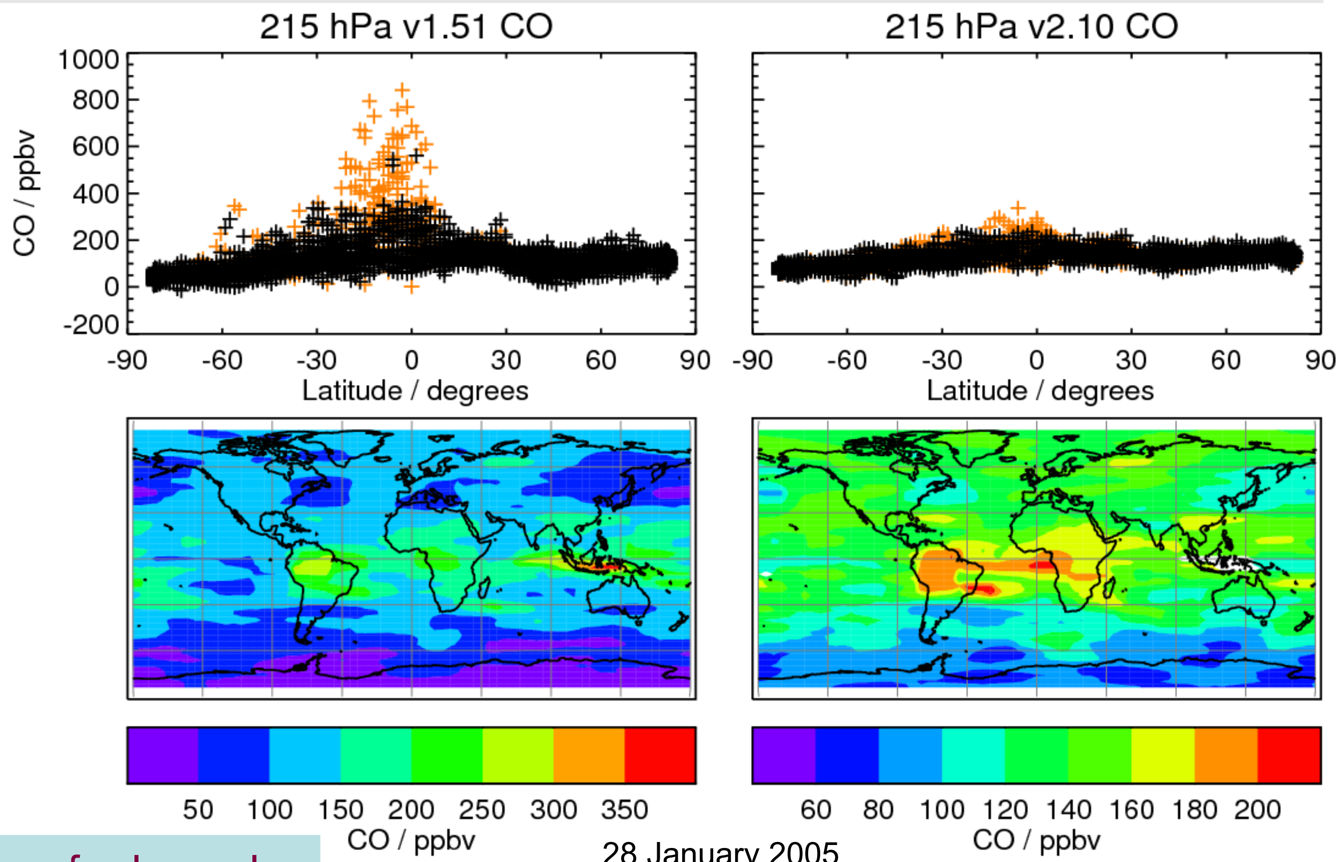
MLS version 2.x data processing

- Version 1.5 started production in January 2005
- We expect version 2.2 to be the 'definitive' MLS data set for 2–3 years
  - Reprocessing all the data since launch will take ~1.5 years
  - Version 2.2 processing is planned to start in November 2006

- A few significant days of 'preliminary' version 2.1 data have been generated for this meeting
- Significant improvements in v2.1 over v1.5 include:
  - Better vertical resolution for UTLS temperature and water vapor
  - Less 'noisy' CO in the upper troposphere (see later slide)
  - Elimination of high bias in stratospheric HNO_3
  - Far fewer 'bad retrievals' for OH
  - Improved performance for mesospheric Temperature, H_2O, O_3, CO

Example of MLS v2.1 upper trop. CO

- Comparison of v1.51 (left) and v2.10 (right) 215 hPa CO
- Orange points are those identified as potentially affected by clouds
- Clouds have less impact on CO data than in v1.51
- We also see less ‘fuzz’ in the new data
- This has led to a significant decrease in suspected high bias



Note change of color scales

Planned validation papers from MLS team

Temperature and GPH	Michael Schwartz et al.
H_2O and relative humidity	William Read et al. (upper troposphere) Alyn Lambert et al. (stratosphere / mesosphere, possibly same paper as N_2O)
Cloud ice	Dong Wu et al.
O_3	Nathaniel Livesey et al. (upper troposphere, same paper as UT CO) Lucien Froidevaux et al. (stratosphere / mesosphere) Yibo Jiang et al. (comparisons with sondes and ground based)
HNO_3	Michelle Santee et al.
ClO	Michelle Santee et al.
HCl	Lucien Froidevaux et al.
HOCl	Lucien Froidevaux et al. (short paper, if any)
BrO	Laurie Kovalenko et al.
N_2O	Alyn Lambert et al. (possibly same paper as stratospheric H_2O)
OH, HO_2	Herbert Pickett et al.
CO	Nathaniel Livesey et al. (upper troposphere, same paper as UT O_3) Hugh Pumphrey et al. (stratosphere / mesosphere)
HCN	Pumphrey et al.
SO_2	Read et al. (short paper, if any)
Non-coincident validation	Gloria Manney et al.
SLIMCAT model	Robert Harwood et al.

MLS Science team responsibility updates

David Cuddy	MLS project manager
Lucien Froidevaux	Deputy Principal Investigator, validation; **stratospheric and mesospheric O_3, HCl, HOCl**
Robert Harwood	(Edinburgh) United Kingdom Principal Investigator
Robert Jarnot	Instrument science, calibration and **Level 1** algorithms
Jonathan Jiang	Cloud validation - morphology and model comparisons
Yibo Jiang	Stratospheric and mesospheric O_3, Level 3 algorithms
Laurie Kovalenko	Chemical modeling; **BrO**
Alyn Lambert	Retrieval science; **stratospheric and mesospheric H_2O, N_2O**
Nathaniel Livesey	Principal Investigator; **upper tropospheric O_3 and CO,** BrO
Gloria Manney	Dynamical consistency of MLS data and derived meteorological products
Herbert Pickett	**OH and HO_2**
Hugh Pumphrey	(Edinburgh) **HCN, stratospheric and mesospheric CO**
William Read	Measurement science and forward model; **upper tropospheric H_2O, SO_2**
Michelle Santee	Polar processes; **ClO, HNO_3, CH_3CN**
Michael Schwartz	**Temperature, geopotential height**, and tangent pressure
Hui Su	Upper tropospheric analysis
Joe Waters	Principal Investigator ‘emeritus’
Dong Wu	**Cloud ice water content**